

New technology needs new policy - From component to systems

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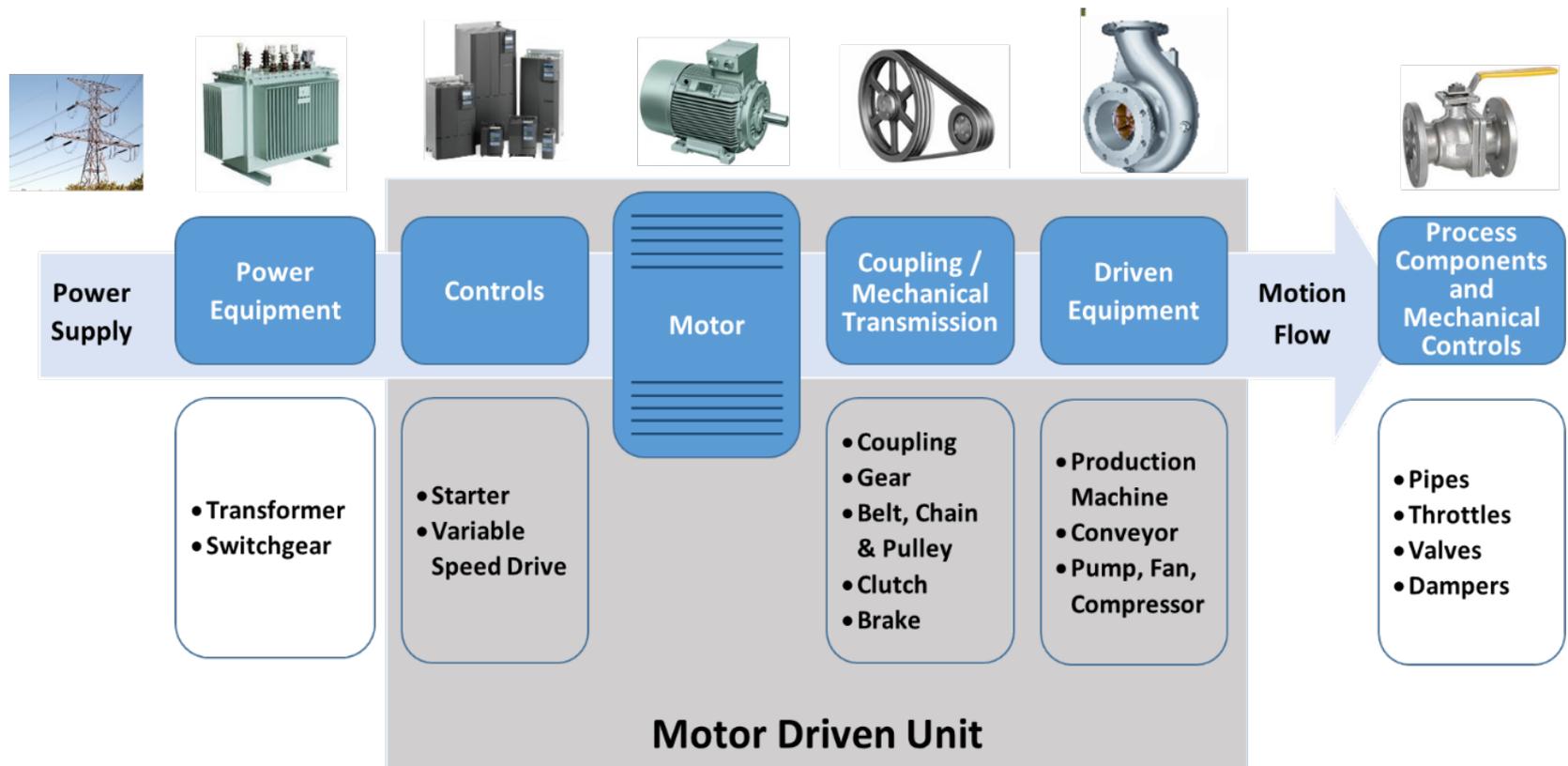
EEMODS 2017, Rome, Italy

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Content

- The problem
 - Big savings from motor ► system
 - Motor Driven Unit (MDU)
- Technology advances
 - Motor technology
 - VFD loss
 - System integration
 - Fixed speed ► variable speed
- Policy follows
 - New standards
 - Motor MEPS
 - MDU MEPS

Motor System efficiency

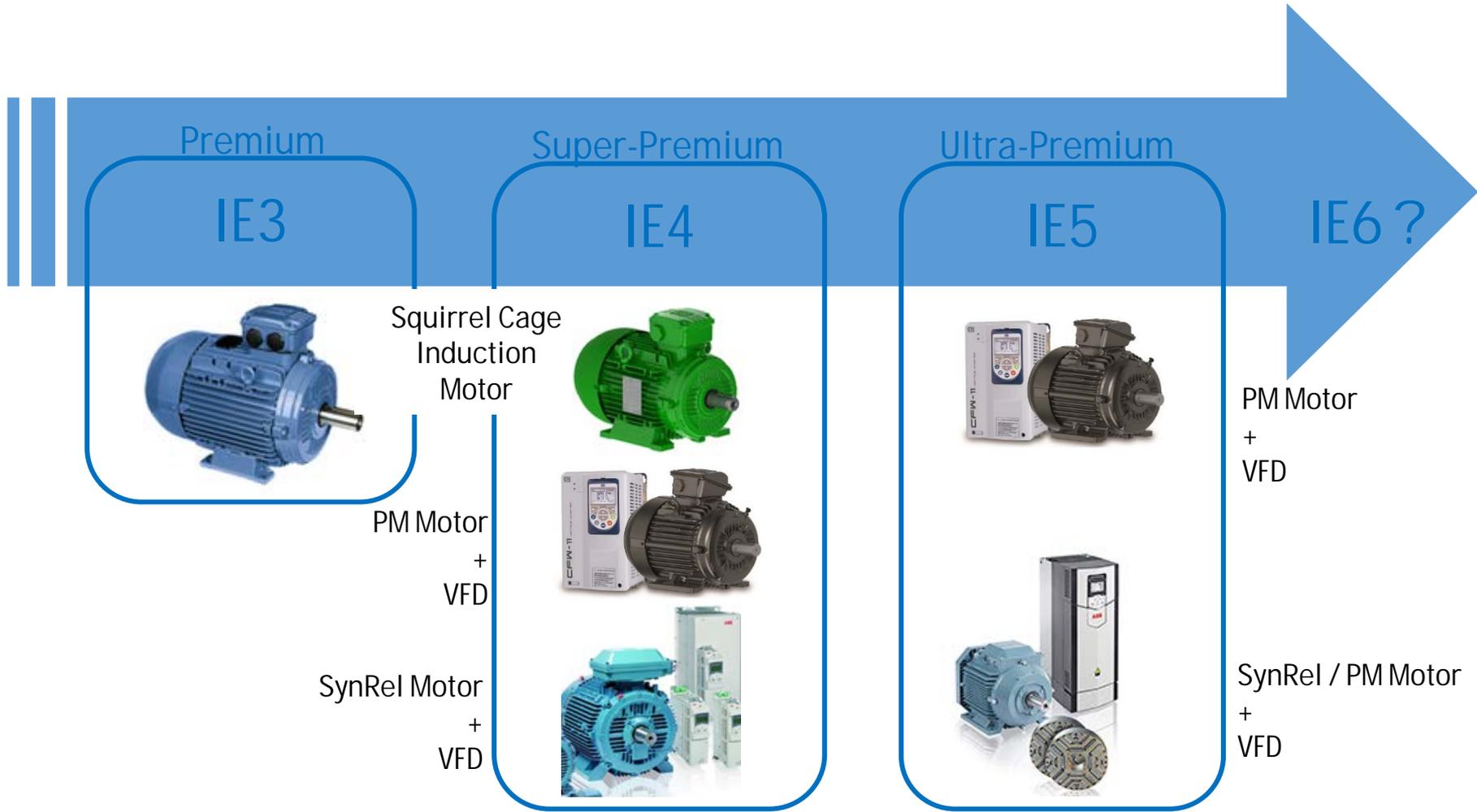


$$\eta_{\text{system}} = \eta_{\text{power equipment}} \times \eta_{\text{controls}} \times \eta_{\text{motor}} \times \eta_{\text{transmission}} \times \eta_{\text{driven equipment}} \times \eta_{\text{components and controls}}$$

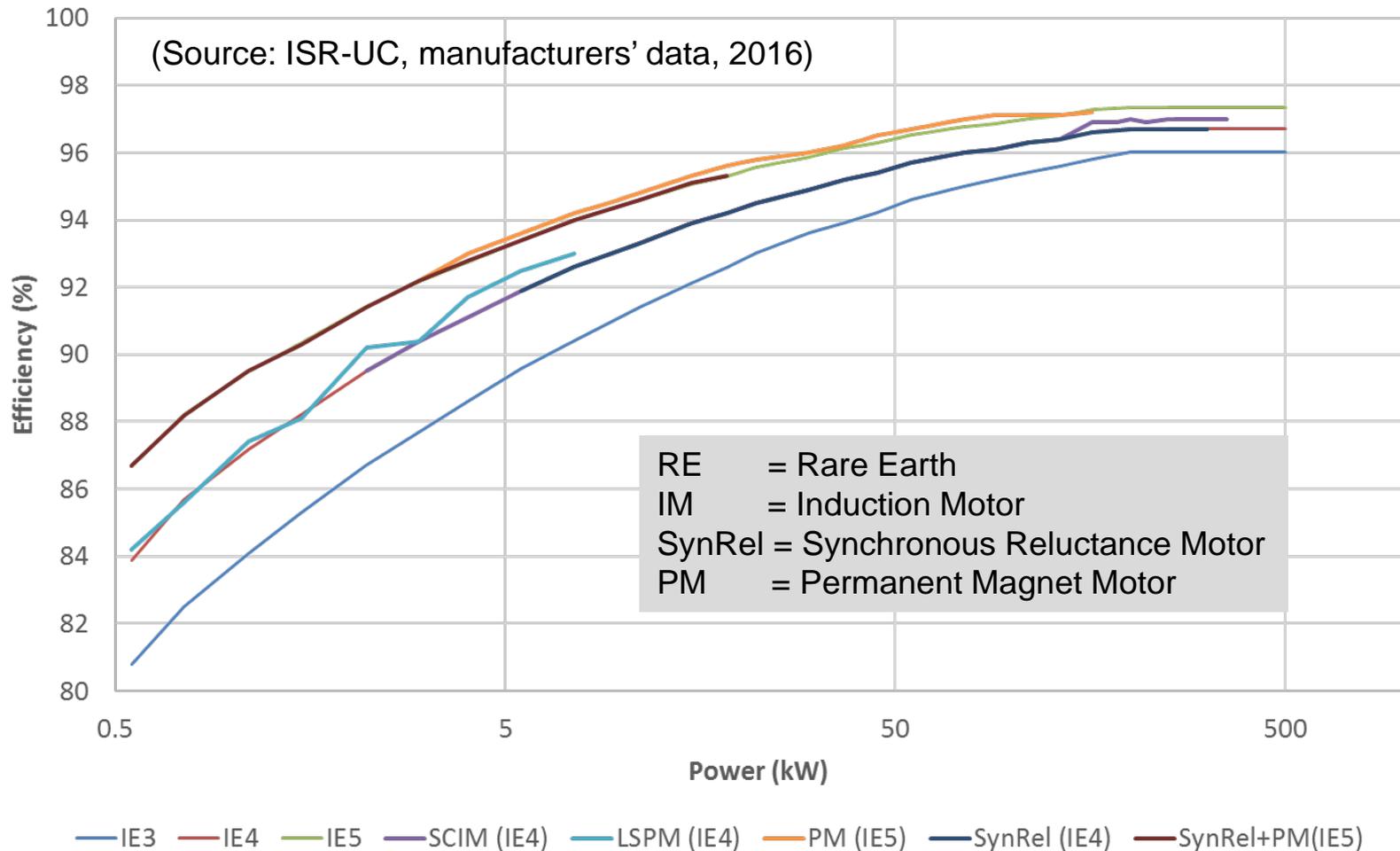
Electric Motors

IEC 60034-30-1: ed.1 (2014)

Motor Efficiency Evolution



Efficiency of commercially available IE4 and IE5 motors (catalogue data)

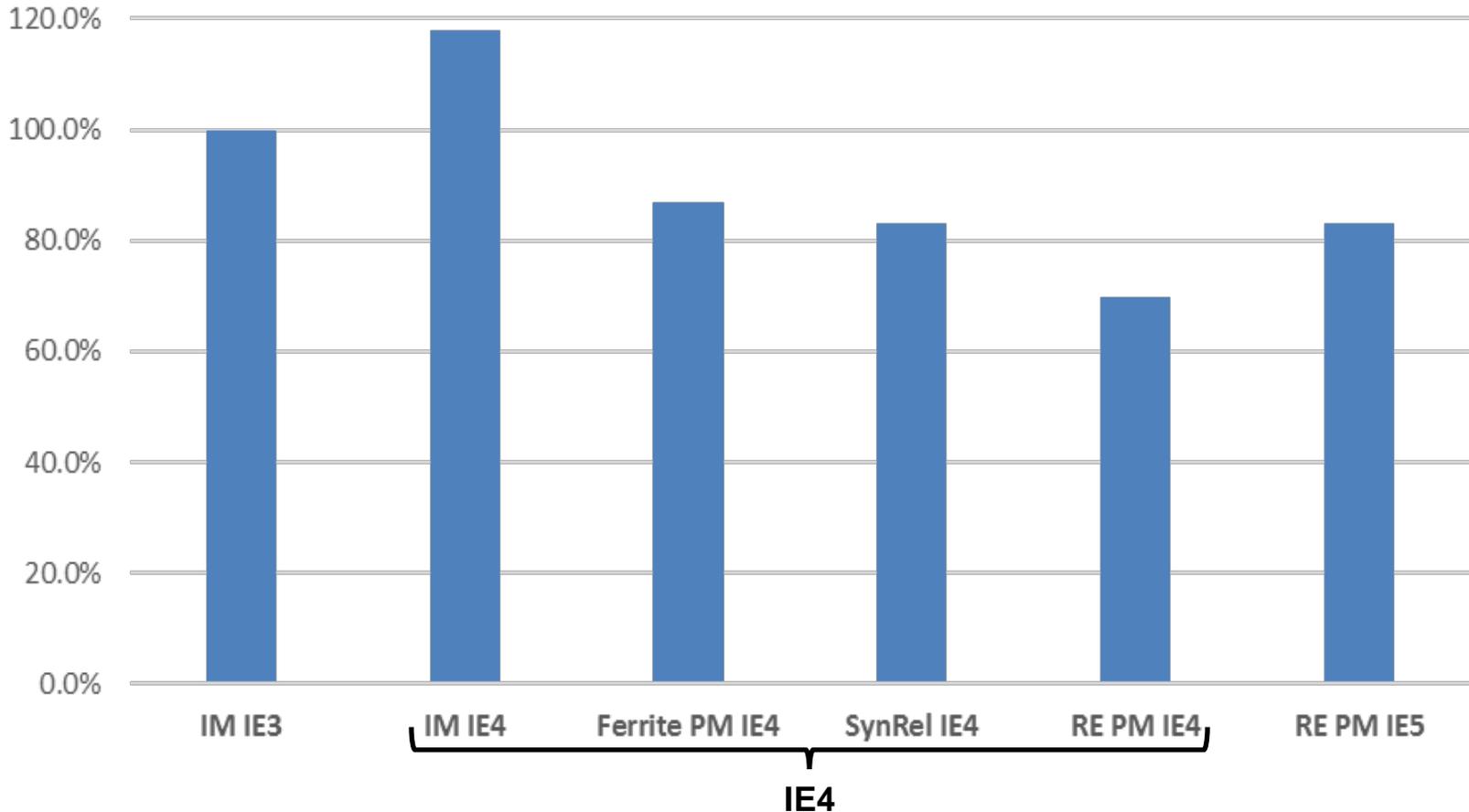


Motor total weight

2016 catalogue data

Basis: 11 kW; 1500 rpm; aluminium frame
RE = Rare Earth
IM = Induction Motor
SynRel = Synchronous Reluctance Motor
PM = Permanent Magnet Motor

(Source: ISR-UC, manufacturers' data, 2016)



Rare Earth Magnet Disadvantages

- Price instability / uncertainty due to concentrated production (> 70% is in China).
- Limited supply of Dysprosium.
- Environmental impact of extraction / processing.



Baotou, China

New / Alternative technologies

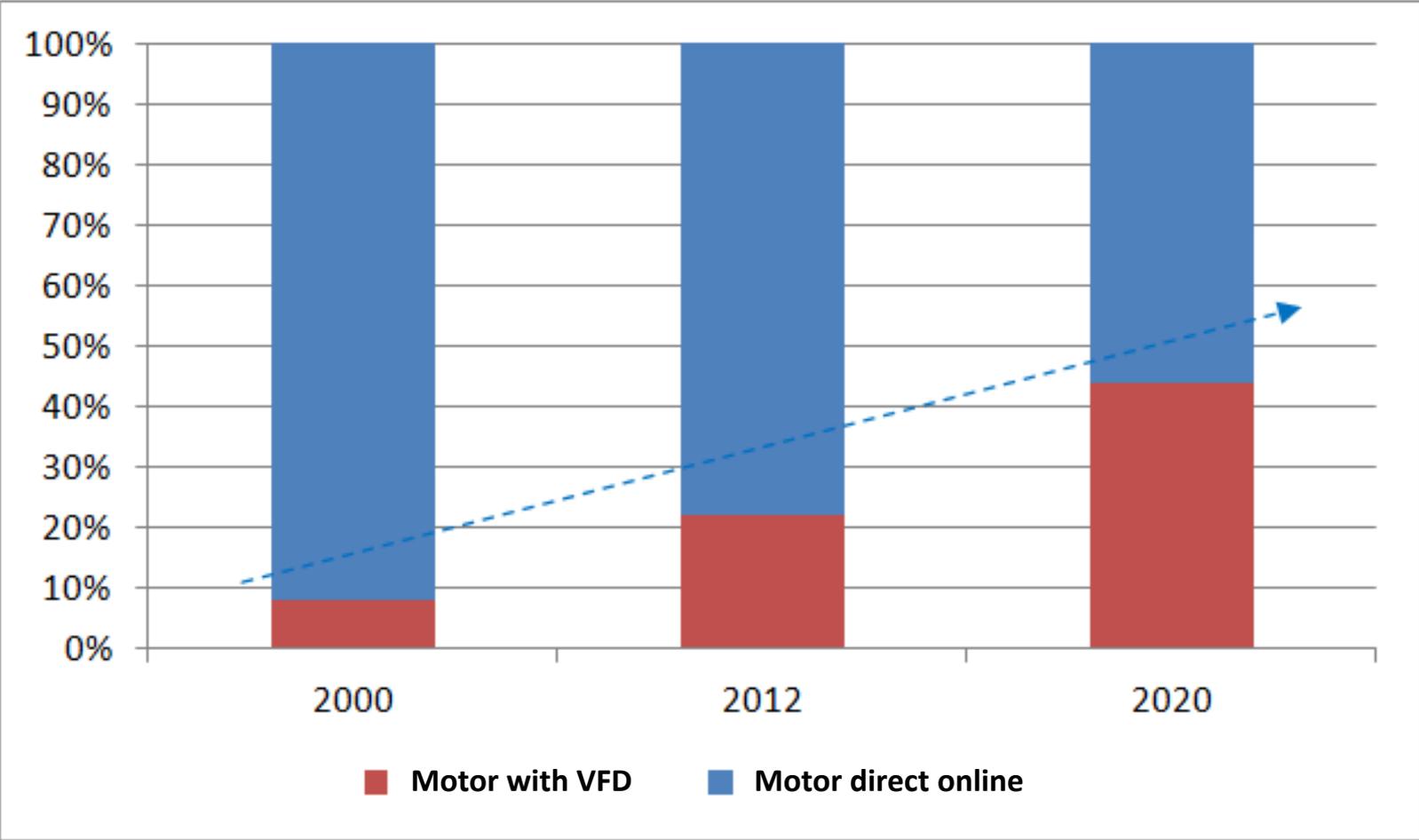
- Reduced-Dy magnet technology (e.g. Hitachi's dysprosium vapor deposition diffusion technology).
- Recycling (limited by economic feasibility).
- Development of new magnetic materials (some not yet commercially available):
 - Iron Nitride, Samarium Iron Nitride, Cerium and Manganese-based compositions, magnetic nanoparticles and Iron Lithium Nitride.
- Using less costly and widely available Ferrite Magnets.



Variable Frequency Drives

VFD market penetration

Sales forecast for 2020 (source: CEMEP)



Motor loss vs. VFD loss

IEC 61800-9-2:2017 © IEC 2017

- Motor loss decreases with higher frequency
- VFD loss increases with higher frequency
- Optimum is between 2 and 6 kHz

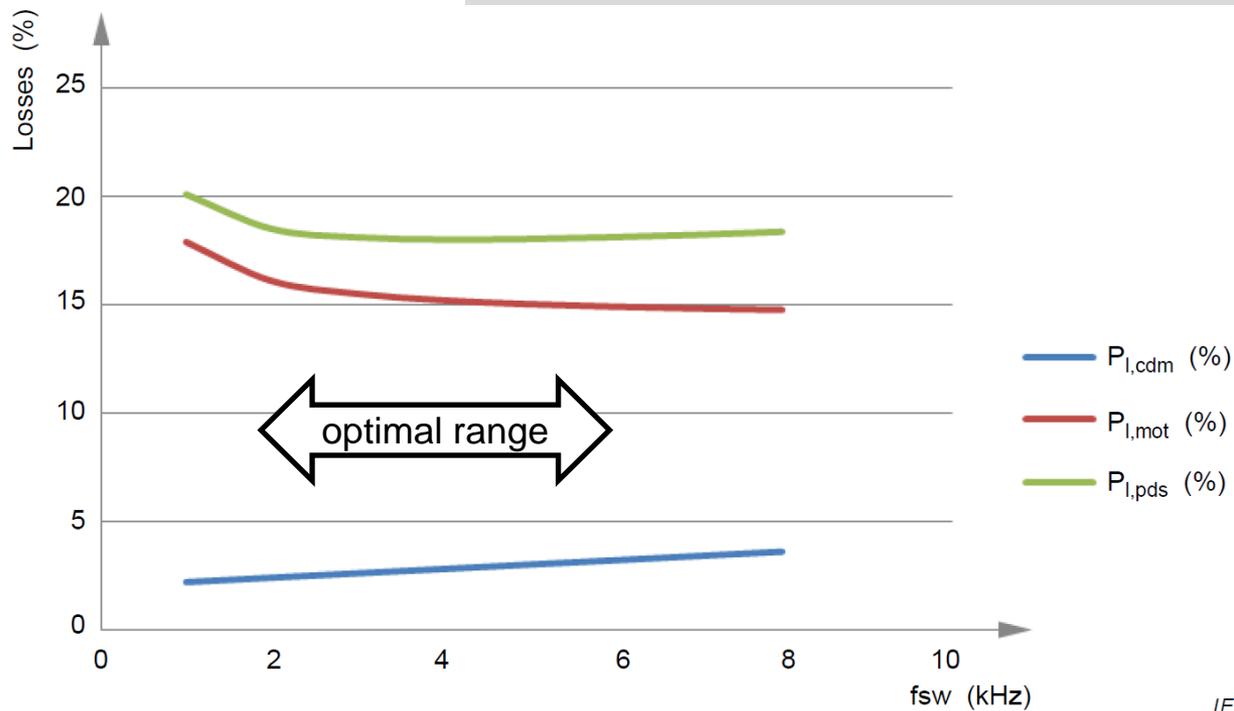
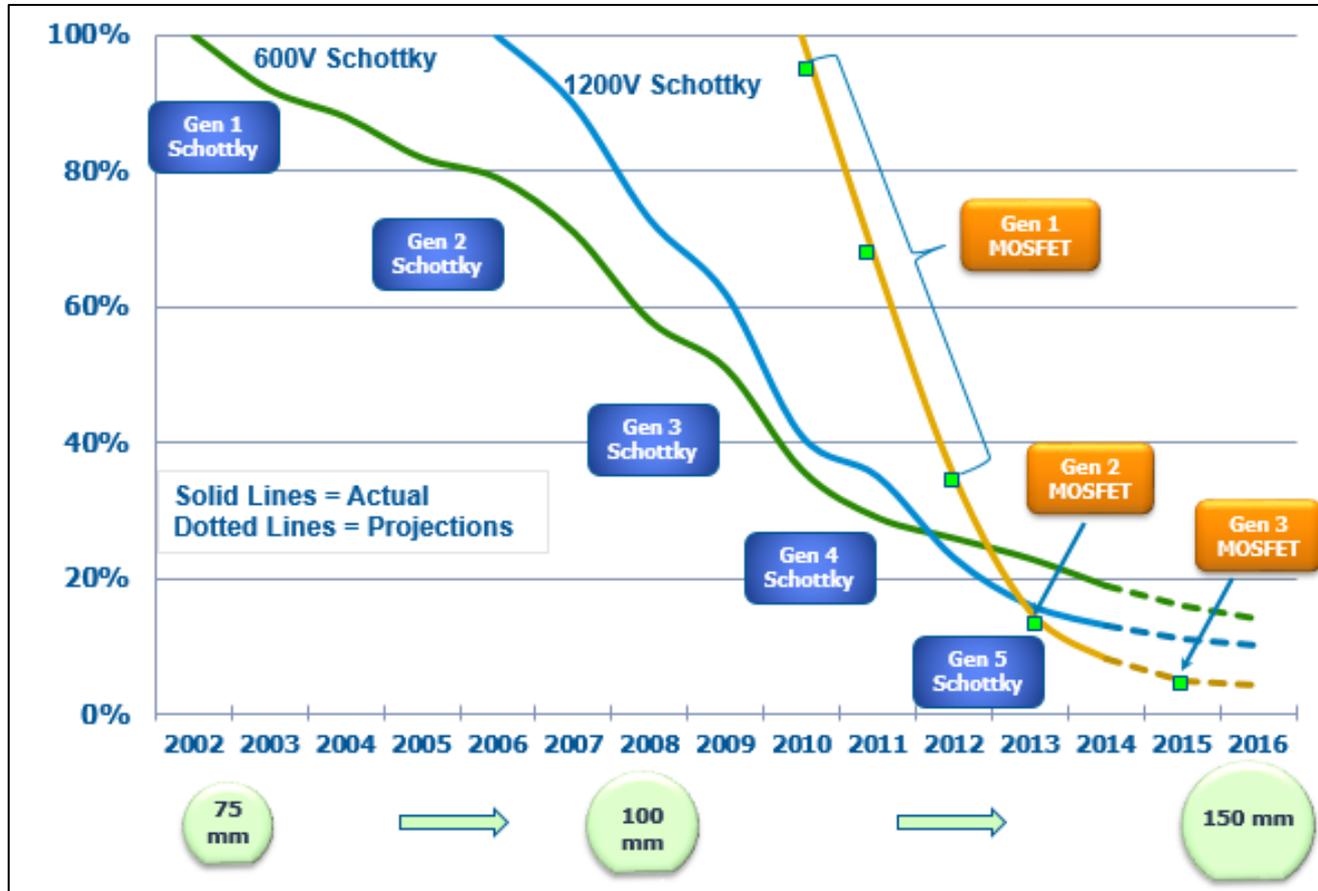


Figure 14 – Example of the relative power losses versus switching frequency

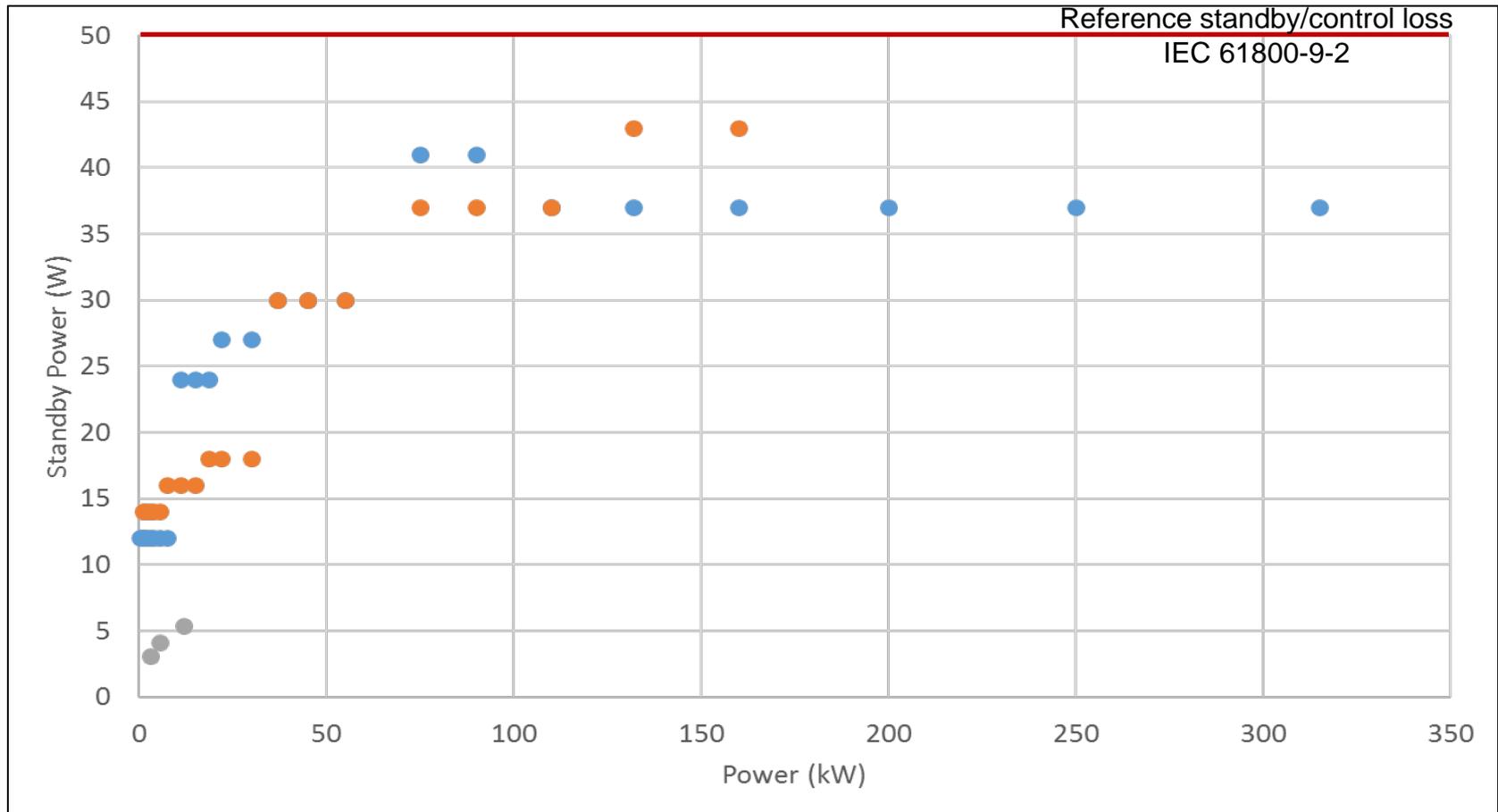
Decline of Device Cost for SiC Products



Source: Cree, Inc.

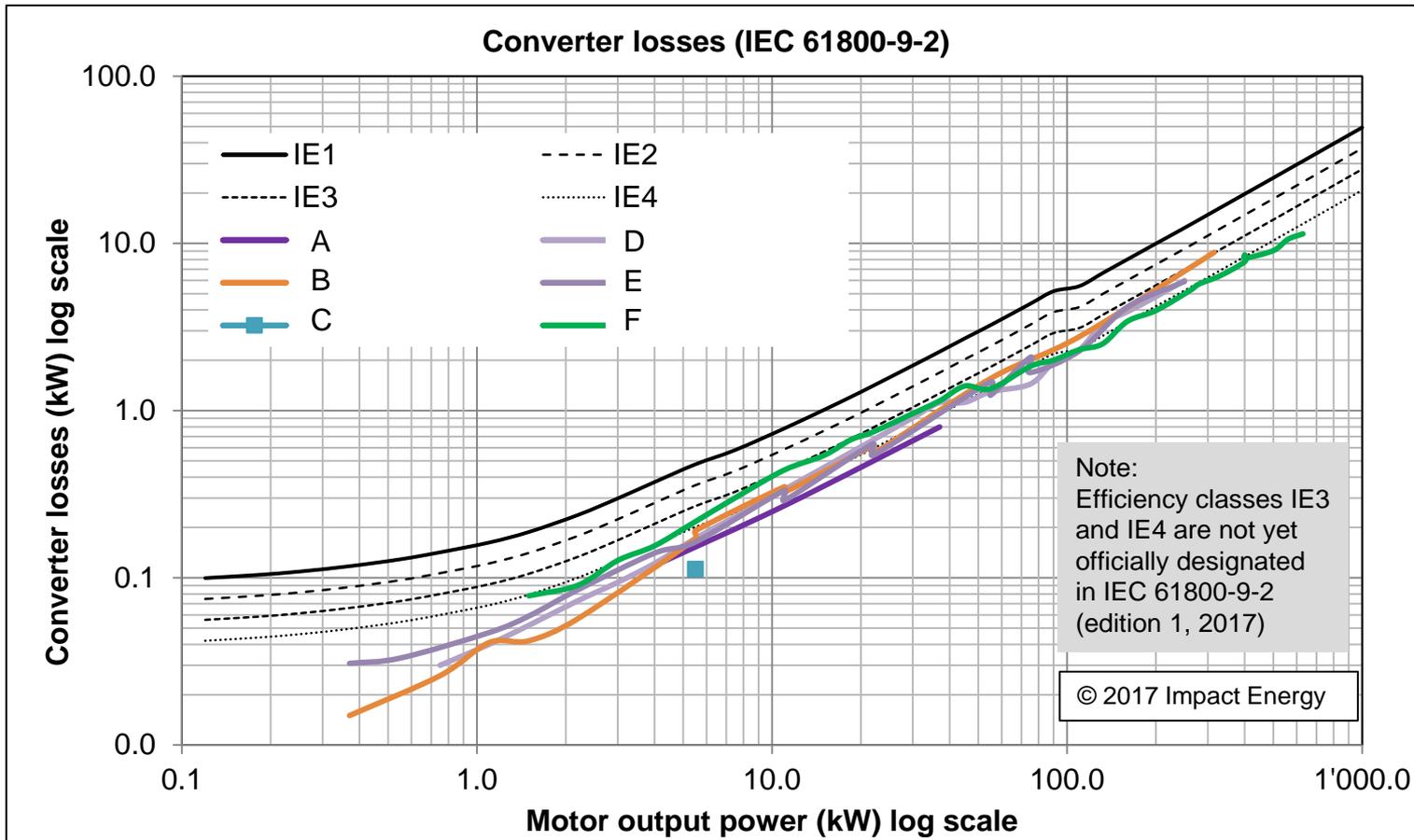
Wide band gap semiconductors can reduce the losses in VFDs (both switching and conduction) by over 50%

VFD Standby Losses



(Source: ISR-UC, manufacturers' data, 2016)

VFD losses: 0.1 kW - 1000 kW



2017 Survey of market products:

- Catalogue and manufacturer's data
- Losses based on IEC 61800-9-2

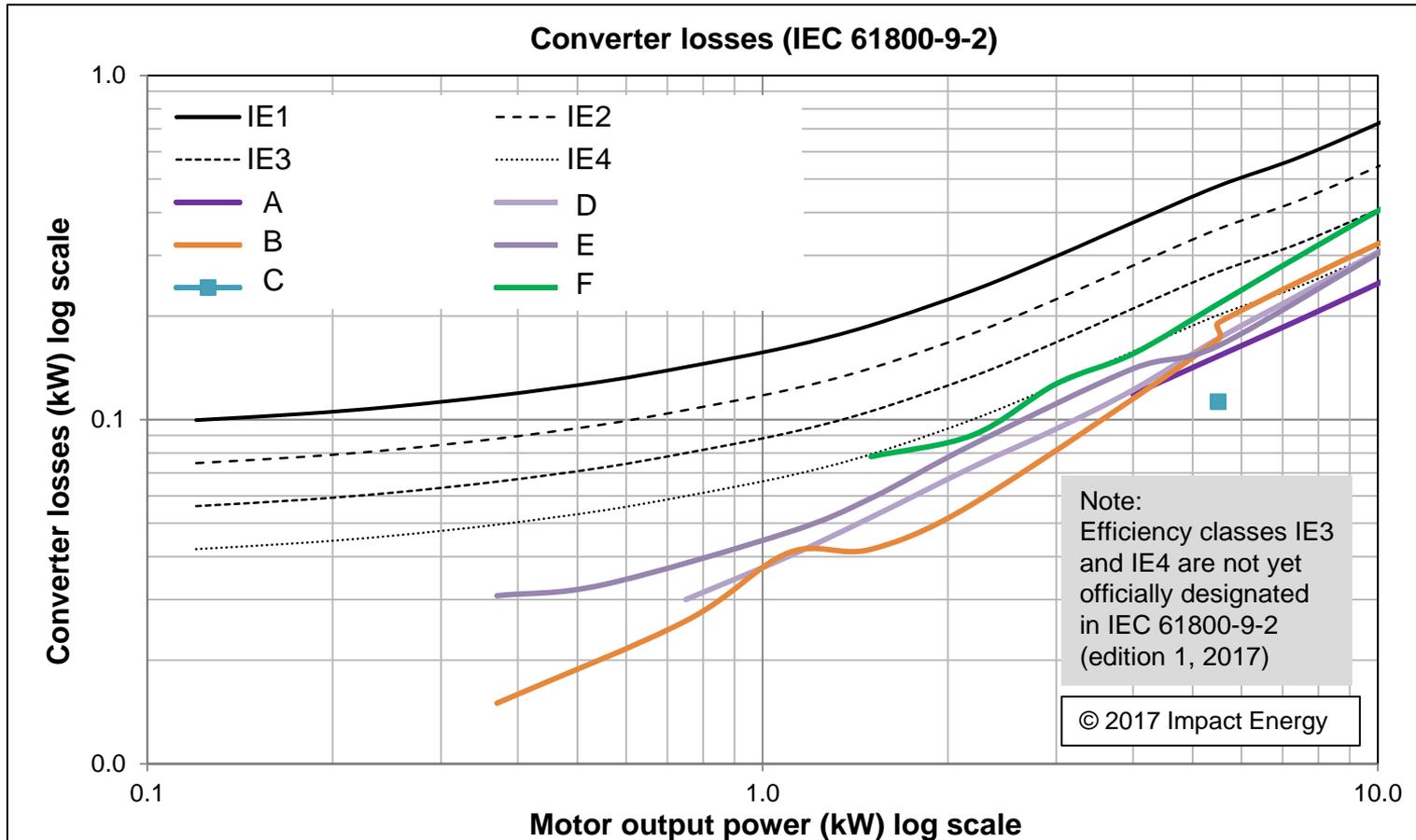
Product range:

- Minimum: 0.37 kW
- Maximum: 630 kW

Data sources:

- 5 VFD manufacturers
- 97 VFD products

VFD losses 0.1 kW - 10 kW



2017 Survey of market products:

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VFD - conclusions

1. Standby and control losses below 50 kW need to be lower
2. Switching frequency should be in optimal range
3. Reference loss in IEC 61800-9-2 is too high, especially below 5 kW
4. Additional efficiency classes IE3, IE4 are needed to distinguish good products
5. Part load efficiencies are pretty low!
6. MEPS can be
 - today at IE2 (no products excluded!)
 - in 2-3 years at IE3 (starts to make a selection)
 - later IE4 (only efficient products)

Standards

Current component standards

Electric Motors/VFD

▶ IEC

- Motors:
IEC 60034-x
- VFD:
IEC 61800-9-x

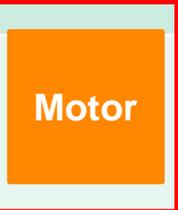
Mechanical components

▶ ISO

- Pumps:
ISO 9906
- Fans:
ISO 5801/ 13349/ 12759
- Compressors:
ISO 1217 /5389/ 5390/
12942

IEC standards for motor systems



		Scope	Testing	Efficiency classification
1		motor	IEC 60034-2-1 ed 2: published 2014	IEC 60034-30-1 ed 2: published 2014
2	 	motor, driven by a VFD	IEC 60034-2-3 ed 2: CD 2017	IEC TS 60034-30-2 Technical Specification spring of 2017
3	 	VFD	IEC 61800-9 IEC 61800-9-1 Extended Products IEC 61800-9-2 VFD Classification/Testing published March 2017 edition 2: work starts now	
4	 	Motor + VFD		

IEC = International Electrotechnical Commission

VFD = variable frequency drive

MDU Standards



IEC 61800-9-1 (edition 1, 2017)

- Adjustable speed electrical power drive systems - Part 9-1:
- Ecodesign for power drive systems, motor starters, power electronics and their driven applications
- General requirements for setting energy efficiency standards for power driven equipment using the extended product approach (EPA) and semi analytic model (SAM)

Not a big comfort: no convincing solution as of now

Policy

System MEPS: added complexity

- **Dual MEPS:** dual burden?
 - Components > and integration (interaction)
 - MDU (wire to water/air) > BLACK BOX
- **Easy:** small integrated products (< 2 - 5 kW)
 - circulator
 - fan
 - compressor
- **Complex:** larger composite machines (>> 5 - 1000 kW)
 - several manufacturers
 - components meet on factory floor only
 - reference motors, etc. for type test

The challenge - added complexity

- **For regulators**

- check every component (or only the entire MDU)
- accept physical tests only (or AEDM: calculation)

- **For standard makers**

- within IEC (or ISO):
several TCs: joint working groups
- collaboration IEC / ISO:
different tradition, culture, procedures

Controls influence motor (further losses)



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